

# Using GIS as a Management Tool for Health Care Assessment and Planning

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## Abstract

One of the primary goals of public health, and of many health care providers, is to maximize the impact and effectiveness of limited resources in improving health care. Of particular interest are the availability and accessibility of health maintenance organizations (HMOs) to sections of the population that have the greatest need. Studies have shown that elderly populations benefit most from such health care services because many of them live alone, have limited incomes, and have high medical costs due to poor health. In the area of public health and health care management, geographic information system (GIS) technology has emerged as a powerful tool for integrating and communicating information, a tool that offers significant advantages over traditional methods for health surveillance. In this study, GIS techniques were used to determine the spatial distribution of health care facilities and analyze patterns in that distribution with respect to elderly populations in the state of Iowa. The purpose of this study was to demonstrate the role of GIS in health care and to develop a spatial analysis and modeling support system for forecasting future health care needs and planning health management programs.

Keywords: health care, facilities siting, decision support system

## Introduction

Several studies have used geographic information systems (GIS) to address issues in health care planning and to examine the accessibility of health care centers to particular sectors of the population. GIS has been used in risk assessments, site selections, health surveillance, epidemiological studies, and other areas in the health care sector (1). Although the specific approaches have varied, GIS has proven to be a powerful system for spatial analysis and decision-making.

## *Demographic Changes in the Elderly Population*

In the United States, the elderly (age 65 or older) population has grown significantly faster than the nation's total population. During the 20th century, the total population in the United States tripled while the elderly population increased by a factor of 11, going from 3.1 million in 1900 to approximately 33.5 million in 1995. The states with the highest proportion of elderly people in 1993 were Florida, Pennsylvania, and states in the Midwest. The states with the highest proportion of people 85 years old and older were all in the Midwest, with Iowa ranking the highest, followed by North Dakota, South Dakota, Nebraska, and Kansas. Currently, the elderly population is not rising, but this is expected to change after the year 2000. According to the US Census Bureau's

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middle series projections,<sup>1</sup> the elderly population is expected to reach 39.4 million in 2010, 79 million in 2030, and 80 million by the year 2050 (2). One of the primary reasons for such a dramatic rise is the aging of the baby boom generation. The baby boom generation consists of the 75 million people born between 1946 and 1964. Iowa is one of the states expected to have the greatest proportion (between 2.5% and 3.8%) of persons age 85 and over during the period between 2010 and 2030 (3). The aging of the baby boom generation will increase Iowa's need for health care services.

### ***National Health Care Issues***

Healthy People 2000, a comprehensive federal agenda for national health care, has recognized the need to identify issues that pose a threat to health and to attempt to address those issues in the public and private sectors. One of the overall objectives of Healthy People 2000 is to increase people's access to preventive health care services. Accessibility of health care facilities is important because it indicates how effectively health care facilities are serving the community. A group's level of access to health care facilities also reflects its mobility, as well as its spatial separation from certain destinations (4).

Spatial separation from health care facilities may be particularly significant for the elderly population. Health care facilities tend to be distant from elderly populations, despite the fact that the elderly have a greater need for health care services because of their increased chronic illness and morbidity. Research suggests that the locations of health care providers are not always based on health needs. The distribution of physicians, for example, is often clustered in the inner city around large hospitals (5). A study published by the New England Journal of Medicine concluded that communities with fewer than 180,000 people may be too small to support effective competition among HMOs (6). Thus, the location of HMO providers may cause problems for smaller populations; HMOs have prospered in areas with larger populations and persons must live within an HMO's service area to receive coverage from it.

Studies also indicate that some elderly persons rely on hospital emergency rooms for primary health care because few of them have personal physicians. In 1995, older persons accounted for 38% of all hospital stays and 48% of all days of care in hospitals; persons under 65 had an average hospital stay of 4.5 days while persons over 65 had an average stay of 6.8 days (7). With the limited numbers of health care providers available in any one area, health care resources become competitive between the elderly and people with fewer financial and physical limitations. These issues can create serious implications for the future of health care, especially considering the expected demographic changes.

Our analysis was guided by several questions related to the expected growth of the nation's elderly population. First, how are the locations of health care facilities distributed in relation to elderly populations with the greatest need? Second, are the health care facilities near enough to those elderly populations? Third, will the locations of health care facilities be sufficient given the projected demographic changes in elderly populations? The focus of this study is to assist in the targeted delivery of health services by identifying areas of need. The emphasis is not on explanation, but on producing

<sup>1</sup> The US Census Bureau's middle series (as opposed to high or low series) projections are made based on the assumption that past and current trends will continue.

an estimate of the variation in health care needs across an area, allowing for the variations in factors such as population age structure.

## **Methodology**

The study was done using the ArcView GIS software package (ESRI, Redlands, CA). GIS techniques were used to analyze the spatial distribution of health care facilities by mapping their locations, then evaluating the distance between the facilities and areas with high concentrations of elderly persons. Demographic characteristics of the elderly populations for 1995 as well as projected trends for the year 2000 were examined.

The area chosen for analysis was the entire state of Iowa, which has 99 counties. The state's total population in 1995 was 2.8 million.

### ***Data Collection and Preparation***

Several considerations were made in deciding on the data to be included in the study. One of the problems addressed was how to locate elderly populations in Iowa. The unit of geographic analysis chosen was the census block group. As of 1995 and 2000 (projected), Iowa has 2,939 block groups. Of those, Polk County has approximately 317 block groups and seven hospitals, Johnson County has close to 63 block groups and four major hospitals, and Sioux County has 27 block groups and three major hospitals. Available attributes of the block groups include the percentages of men and women in different age groups, with people 85 and older making up the oldest group. Block group census data from the years 1995 and 2000 (projected) were linked to create one table of information.

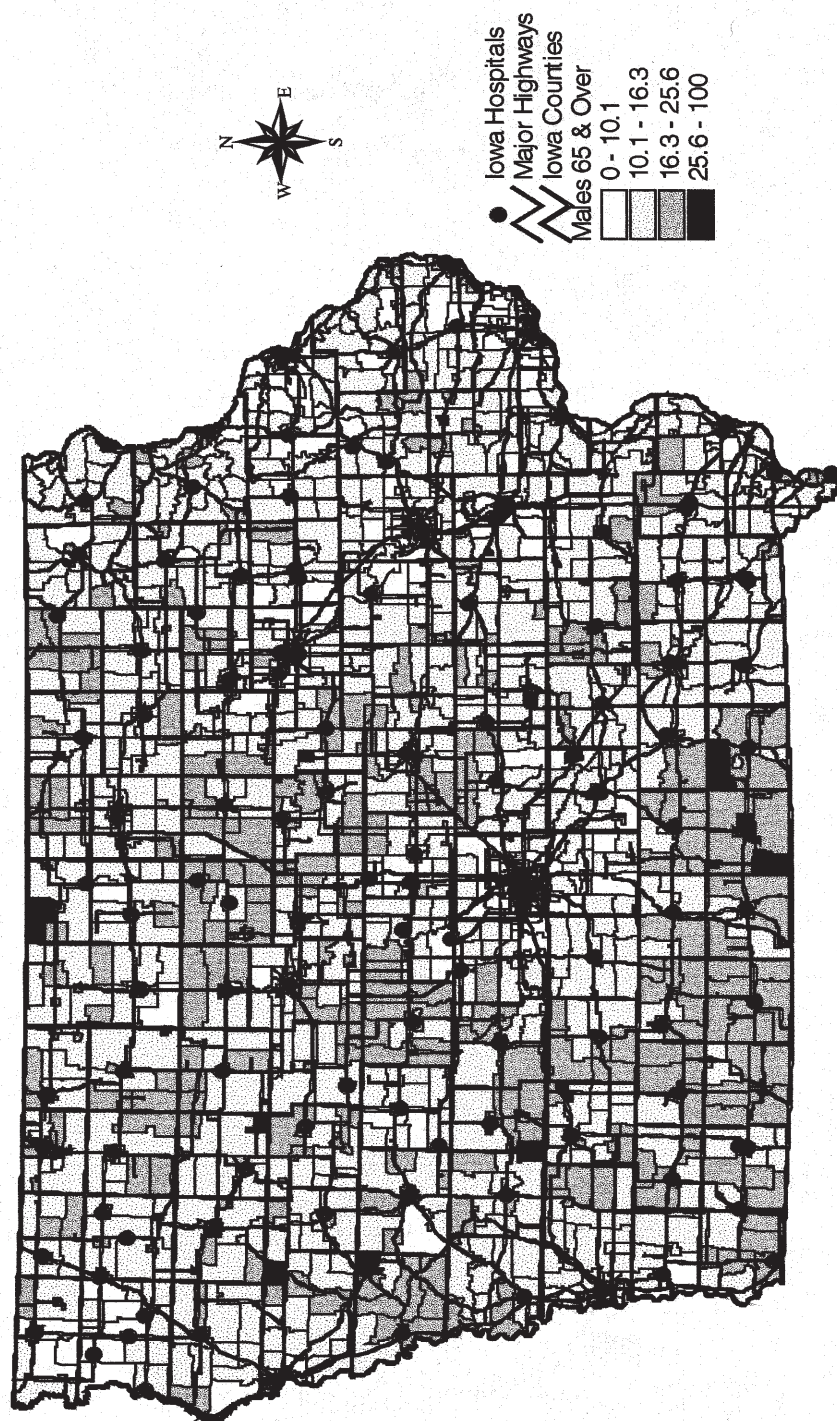
Another consideration was the choice of health care providers to include in the study. There is a wide range of HMO providers: medical groups, individual physicians, physician-staffed health centers, and hospitals. In this study, hospitals were chosen as the primary source of HMO providers. The dataset of hospital locations for Iowa listed 137 hospitals in total. Data on Iowa hospitals include each facility's address, county, number of beds, and accreditation.

Another factor in the selection of data was the question of how to measure the accessibility of hospitals to elderly populations. The approach chosen was to measure distances between hospitals and selected groups of elderly populations. The analysis also included a map of major highways in Iowa. The coverage of highways contains a database of 1,821 major highways in Iowa.

Maps of hospital locations, block group boundary files, and major highways were all obtained from the Iowa Department of Natural Resources and imported into ArcView GIS. These parameters were used to measure accessibility of Iowa hospitals to elderly populations and were linked to a map of Iowa counties for analysis.

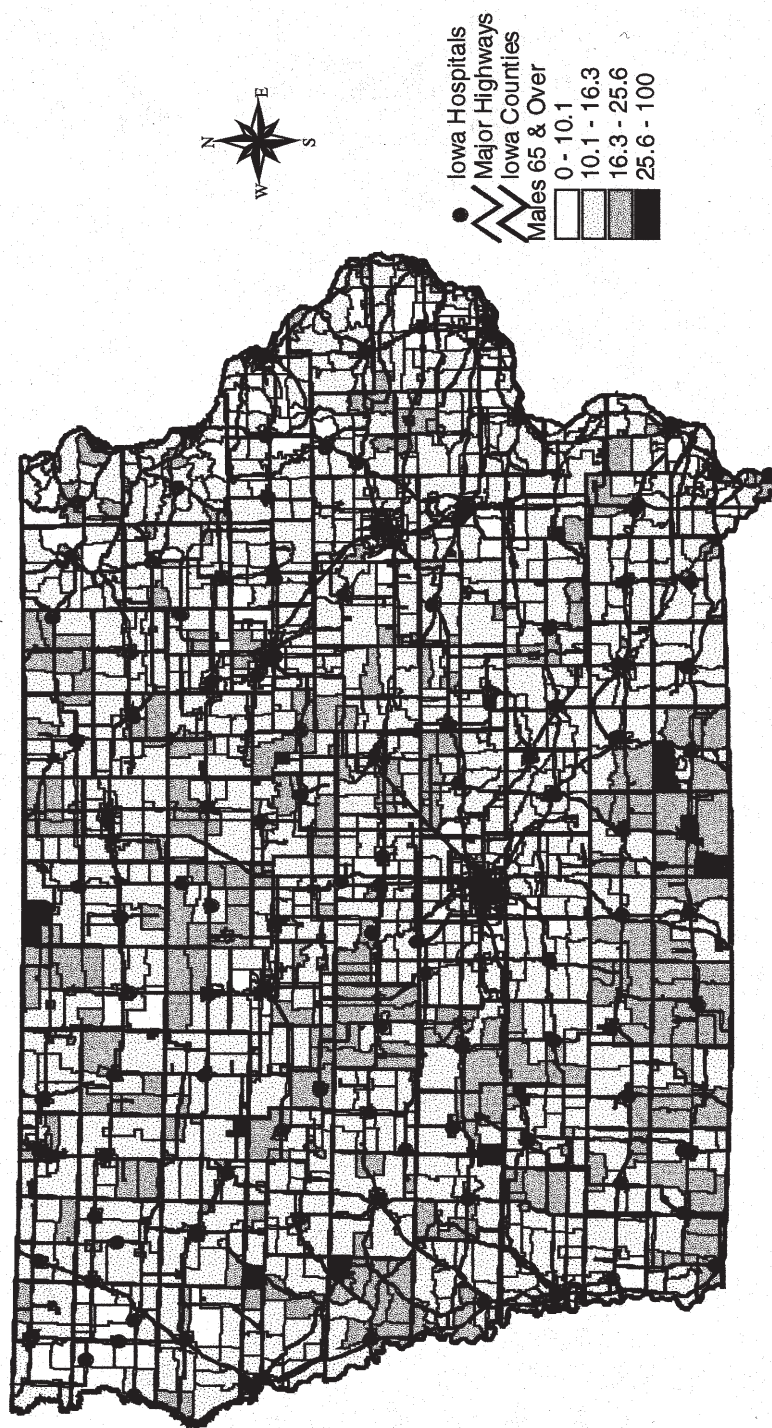
## **Measuring Accessibility**

At the beginning of the analysis, a group of populations was selected for evaluation. The selection was based on block groups that had the highest percentages of elderly men and women in 1995 and 2000 (projected). Because elderly women significantly outnumber elderly men, different criteria were used for selecting target block groups. The block groups targeted were those in which the elderly population in a block group exceeded 25.6% for men and 38.6% percent for women (Figures 1–4). Of the 2,939 block

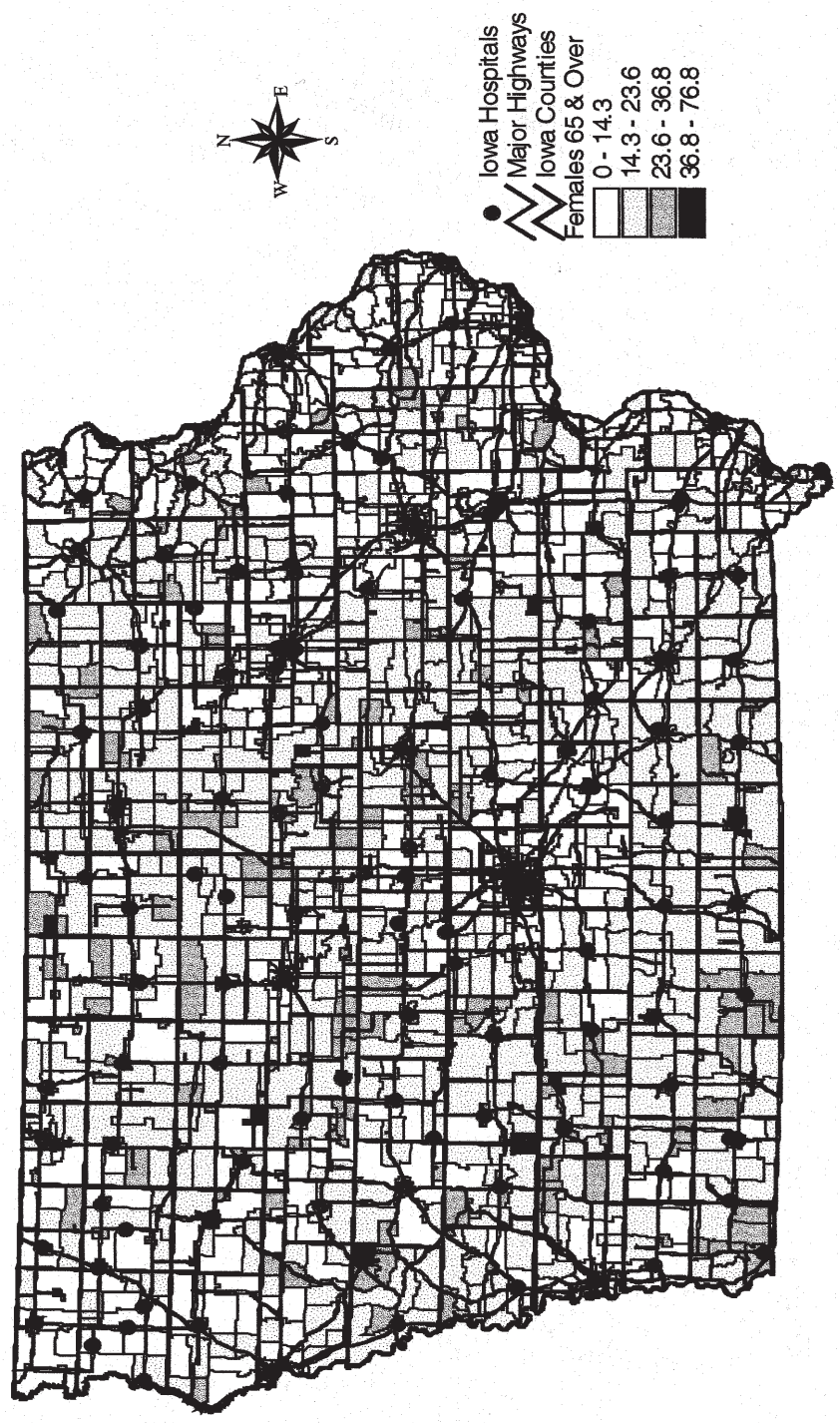


**Figure 1** Elderly men and accessibility of major Iowa hospitals in 1995.

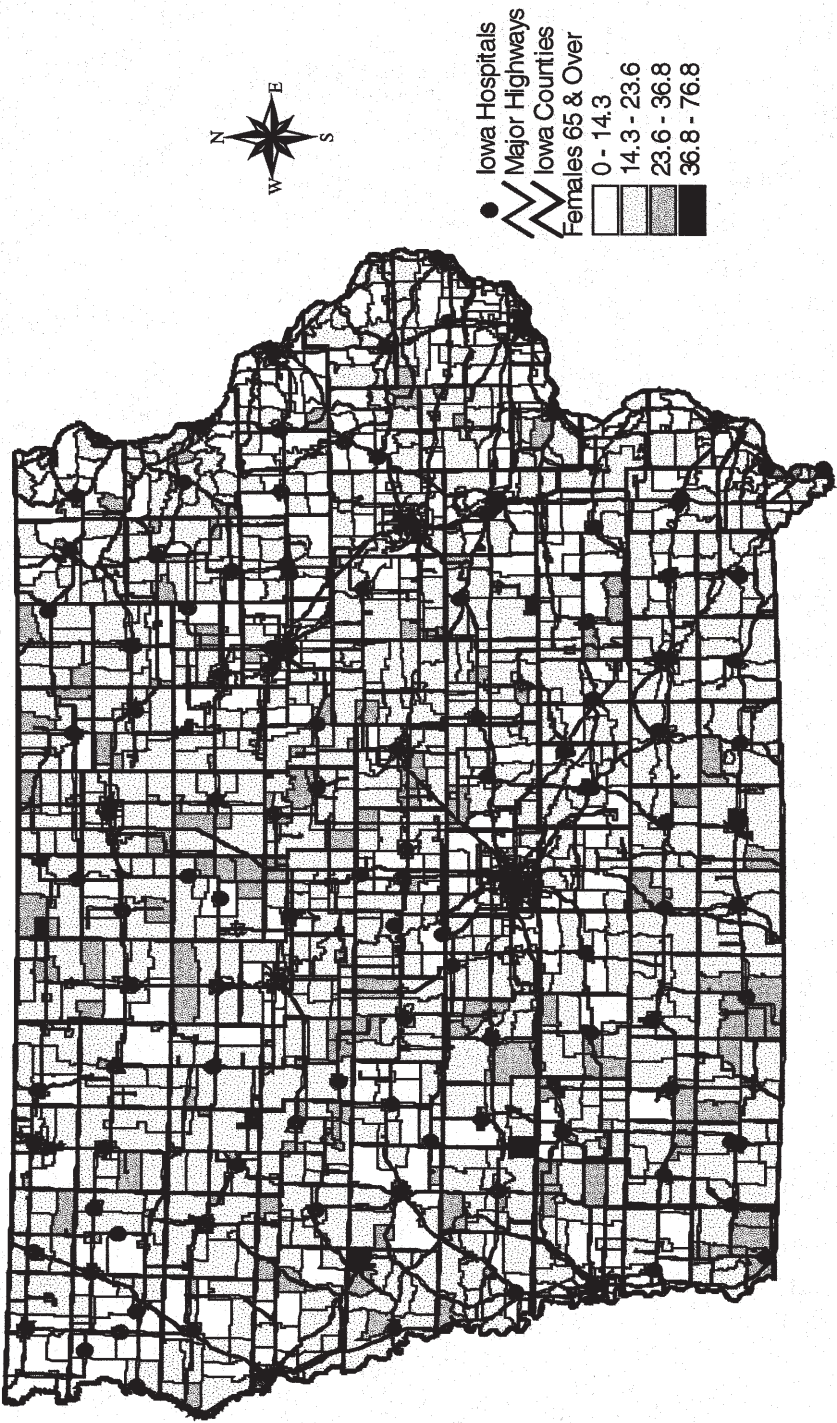




**Figure 2** Elderly men and accessibility of major Iowa hospitals in 2000.



**Figure 3** Elderly women and accessibility of major Iowa hospitals in 1995.



**Figure 4** Elderly women and accessibility of major Iowa hospitals in 2000.



groups in Iowa, 3.33% of the block groups were selected for men (98 targeted groups) and 3.84% were selected for women (113 targeted groups). The number of block groups selected for analysis was the same for 1995 and 2000 (Table 1).

**Table 1** Percentage of Block Groups in Iowa Identified for Evaluation

| Block Groups Evaluated              | Evaluated Block Groups as a Percentage of All Block Groups in State |
|-------------------------------------|---|
| 38.6% or more elderly women in 1995 | 3.84%   |
| 25.6% or more elderly men in 1995   | 3.33%   |
| 38.6% or more elderly women in 2000 | 3.84%   |
| 25.6% or more elderly men in 2000   | 3.33%   |

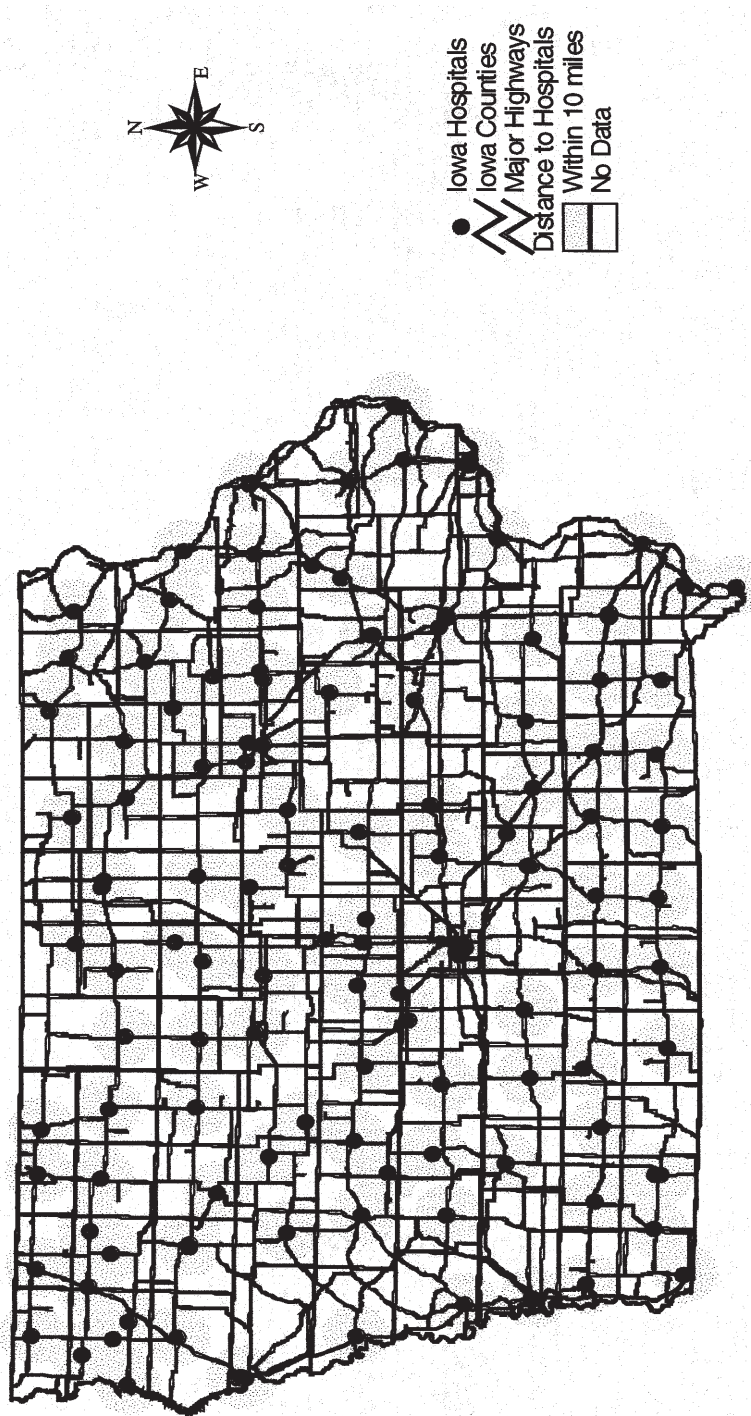
Most of the analysis for the selected block groups was done using the Spatial Analyst extension in ArcView GIS. The distance mapping capabilities of ArcView GIS were used to create a grid coverage of distances to all hospitals. For the state analysis, uniform circular buffers of 10 miles were created around all hospitals and targeted groups (Figure 5). It was assumed that 10 miles would be the maximum traveling distance desired by persons in need of services at nearby hospitals. The proximity mapping function of ArcView GIS was used to display hospital service areas and identify the hospitals nearest to the elderly populations that do not have access to nearby facilities. A county analysis was done for Polk, Johnson, and Sioux Counties, which all have a large number of health care facilities compared with other counties in Iowa. The county analysis was done because, due to the large number of health care facilities in Polk, Johnson, and Sioux Counties, some populations may need to travel to these counties for special services (Figure 6). Uniform circular buffers of 50 miles were used for the county analysis.

## Results

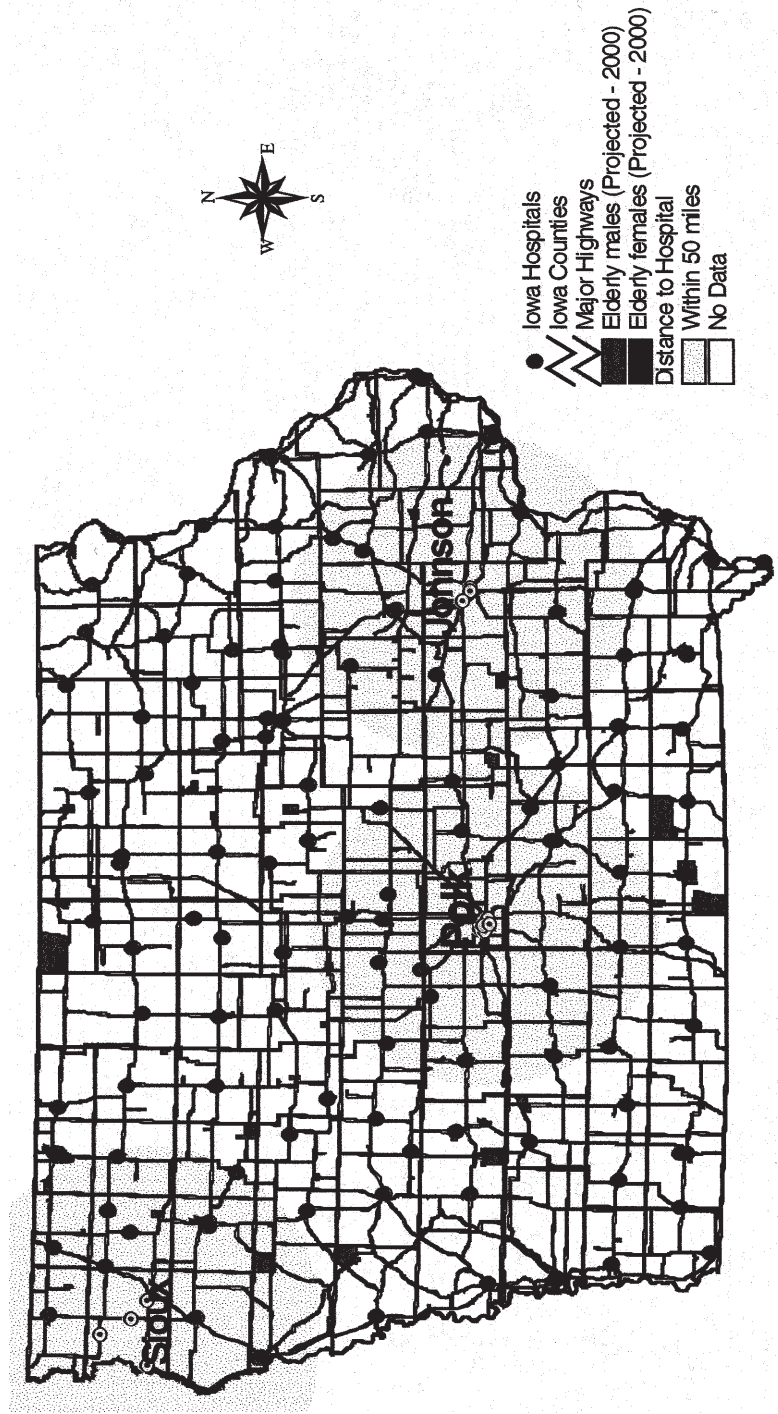
Iowa's elderly population, male and female, did not grow significantly between 1995 and 2000. Based on the classification of the elderly (Figures 5 and 6), the percentages of men and women within block groups remained about the same, although there were changes in population numbers. This was as expected; the percentage of elderly persons was not predicted to change dramatically through the year 2000. However, a greater change would have been seen if demographic data were projected through the year 2030 because this is the period expected to have a rapid increase in elderly populations. The results of the analysis for the accessibility of health care facilities to targeted populations are provided in Table 2.

Percentages of block groups within 10 miles of health care facilities were the same in 1995 and 2000 for both men and women. For men, the number of targeted block groups within 10 miles of a hospital was 79.59% (78 out of 98 targeted groups); 20.41% of the block groups were more than 10 miles away from a hospital. For women, the number of targeted block groups within 10 miles of a hospital was 84.96% (96 out of 113 targeted groups); 15.04% of the block groups were more than 10 miles from a hospital. For both men and women, the block groups that were more than 10 miles away from





**Figure 5** State analysis—10-mile buffers of major hospitals in Iowa.



**Figure 6** County analysis—50-mile buffers of major hospitals in Polk, Johnson, and Sioux Counties, Iowa.

**Table 2** Percentages of Targeted Populations (Defined as Block Groups) within the 10-Mile Buffers of Major Hospitals in Iowa

|  | 1995   |        | 2000   |        |
|--|--------|--------|--------|--------|
|  | Women  | Men    | Women  | Men    |
| Percentage within 10 miles of a hospital | 84.96% | 79.59% | 84.96% | 79.59% |

the nearest hospital were located mostly in the northwest portion of the state. Seven counties in northwest Iowa contained block groups that were targeted for both men and women and were more than 10 miles from the nearest hospital. These counties are Ida, Monona, Sac, Palo Alto, Pocahontas, Calhoun, Webster, Carroll, and Guthrie. Based on the analysis, these areas in northwest Iowa have the greatest need for additional health care facilities.

Polk County has seven hospitals and Johnson and Sioux Counties have four hospitals each. All other counties have one or two major hospitals. Polk County had approximately 18 targeted block groups within 50 miles of one of the seven hospitals. Three of these block groups did not have access to a hospital within 10 miles. There were 17 other health care facilities located in nearby counties. For Johnson County, six targeted block groups were within 50 miles of at least one of the four facilities in Johnson County. Only one of these block groups was not within 10 miles of a hospital. Sioux County had four targeted block groups within 50 miles of its four hospitals. One of the four targeted block groups was more than 10 miles away from a hospital. There are about 12 other hospitals in nearby counties.

## Summary and Conclusions

The objective of this research was to examine the spatial distribution of hospitals and elderly populations in Iowa. For this purpose, GIS techniques were used to analyze the distances of hospitals from block group populations with the highest percentages of elderly men and women, and determine the areas that have the greatest need for health care services. In Iowa, the proportion of elderly persons is expected to increase significantly, which may affect the availability of health care resources in the state. Thus, the results of the analyses provide important information for the assessment and planning of health care facilities.

The main findings of this study are that, in Iowa, there were not significant changes in the number of elderly persons between 1995 and 2000, although the same is not expected after the year 2000; at least 15% of elderly block group populations are more than 10 miles from the nearest hospital; and, most of the block group populations that are more than 10 miles away from a hospital are located in northwest Iowa, which is accordingly identified as the area with the greatest need for additional health care facilities.

The results of the analyses are useful in that they show that distance is a good indicator of accessibility. GIS was a useful tool for identifying elderly populations with the greatest need for health care services. The information obtained could serve as a guide for addressing health care needs in the elderly population at the local, state, and

national levels. Using the information would allow health care officials to plan for future health care facilities and meet national health care goals. These findings could also be a basis for further GIS analysis to examine areas with the greatest need for health care services through the year 2050, evaluate other indicators of accessibility such as distance between hospitals and public bus stops, or analyze the accessibility of nursing facilities to the elderly. Further studies would provide a more detailed look at the needs of the elderly and help state agencies evaluate current needs and plan for future population changes.

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